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Designing a Functional Monitoring Program for Florida Aquatic Preserves

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Introduction

This report is intended to help State estuarine aquatic preserves personnel and other agencies and individuals involved in managing coastal wetland systems develop an environmental monitoring program. The Florida Department of Natural Resources is responsible for the management of the State's aquatic preserves. Presently, there is a relatively small staff and administrative support infrastructure for the aquatic preserve system. Many aquatic preserves do not have full time career service staff assigned to them. Those that do have been consumed with the task of preparing a management plan and reviewing permit requests for activities within the preserve's boundary. As a result, little attention has been paid to conducting a thorough analysis of existing information for the preserves and developing and implementing some sort of long-term monitoring program.

The purpose of this report is to design the framework for a monitoring program that will assess the current status of an estuary and provide data to help the managing agency formulate management strategies that preserve and enhance the natural resources of the system. To accomplish this, a combination of gathering existing information and developing a plan to collect baseline data is necessary. This report provides an outline of how to collect existing information, design and implement a basic environmental monitoring program. Adoption and implementation of this plan by the Bureau of Aquatic Preserves will establish a starting point for the field managers and staff in the analysis of their respective systems. The intended result is to save these individuals many hours of planning and preparation time.

The ideas and recommendations presented in the report are based on our experiences in collecting base line data in the Cape Romano - Ten Thousand Island Aquatic Preserve for this grant and the long term monitoring program for the Rookery Bay National Estuarine Research Reserve and Aquatic Preserve (Thoemke 1985 and Thoemke and Gyorkos 1987).

Why Monitoring Programs Are Important

In recent years, the value and need for monitoring programs has become apparent. Excellent summaries of the purpose and usefulness of monitoring has been discussed by Flemmer et. al. (1983), O'Conner and Flemmer (1987) and Perry et al (1987). In their paper "How should research and monitoring be integrated?", Flemmer et al (1983) point out the most effective management comes from coupling monitoring and research. They define monitoring as, "The systematic sampling and measurement over time of variables which describe the abundance and distribution of biological resources, the distribution and concentrations of physical, geological and chemical properties or the location and rates of significant processes." Research is defined as, "The systematic collection and analysis of experimental and/or field observational data that produces knowledge." The authors state that information learned from monitoring activities serves as the basis for a hypothesis on which research is conducted and the results of research projects often can be used to fine tune monitoring programs.

When planning a monitoring program the questions to be answered are: what are the present conditions withing the system, is the system stressed and are present management policies effectively dealing with the long term goals for managing the area? Answering these questions is essential in determining if new management policies should be developed and implemented. The results of a monitoring program provide the first information about the area that will alert the managers to any problems. Following the pattern of Flemmer et al (1983) the results of the initial monitoring program help to define the types of scientific research necessary to develop management plans that deal with the environmental problems of the area. The research results are used to either define a new monitoring program that can be used to determine if the management actions are sufficient to solve the problems or to recommend different types of monitoring and research programs.

In Florida, management of our coastal resources is especially important. Zwick (1987) states approximately 900 residents move to Florida every day. Because of Florida's peninsular shape, virtually everyone of these residents lives within 50 miles of the coastline. Thus, the impacts associated with each of these residents has the potential to impact Florida's estuaries. As Zwick points out, the result of these residents moving to the state generates a daily need for "nearly two miles of highways, 111,108 gallons of water and produces 94,560 additional gallons of wastewater requiring treatment and creates a 3,546 additional pounds of solid waste." Virtually no one is predicting that these numbers will decrease in the foreseeable future.

An example of the tremendous pressure and threat to the coastal resources of the state can be found in southwest Florida. The coastal areas of Charlotte, Lee and Collier Counties are among the fastest growing regions in the United States. Seven of the State's 40 aquatic preserves are located within these three counties.

Many of the 900 new residents coming to Florida every day move here because of Florida's perceived abundance of high quality natural resources. Yet, as these people move to the state they are largely responsible for the wetlands alterations and destruction that are degrading the natural resources. New housing, roads and other services which are necessary to support growth directly impact wetlands when these areas are filled or impounded. Even upland development indirectly impacts the estuaries. As the vegetation cover and topography of uplands within the estuary's watershed are altered by housing projects, agricultural practices and road and drainage canal construction, the quantity, quality and timing of critical freshwater supplies to the estuary are changing. These changes are the source of most of the environmental and management problems of the estuary.

Florida now has a state comprehensive plan whose purpose is to achieve planned growth for the state realizing the changing political and economic conditions that exist. One goal is to maintain the general quality of life for Floridians. To do this the government's plan is to provide protected and well managed natural resources. Management of our natural resources requires a plan that incorporates monitoring as one of the essential elements of the management plan.

Although not often considered by the general public, estuaries are more important for their economic contributions to Florida than they are for their aesthetic qualities. For approximately 70% of all commercially and recreationally important fish and shellfish harvested in Florida and its adjacent waters, the estuary is a crucial link in the life cycle of these organisms. Without estuarine areas, these organism's life cycles would be interrupted and the numbers of harvestable fish or shellfish would be greatly reduced.

The economic impacts of unhealthy estuaries are felt by not only the commercial fishermen, recreational fishermen and seafood consumers, but by other segments of Florida's economy such as boat builders, businesses which sell boats and related marine supplies, marinas which provide fuel and services for boaters and manufacturers of boating related supplies and equipment whose businesses depend on a need for these recreation items and related services. Milon and Adams (1987) report total Florida retail sales for recreational boating in 1985 totaled 1.3 billion dollars and employed over 23,000 persons in the industry. They also point out that when the indirect impacts of the recreational boating industry are added to the direct economic impact, the total industry economic activity in 1985 was 2.7 billion dollars.

It is in response to the present and potential impacts on Florida's estuaries that the development of a monitoring program is based. In order to manage for the future, we need to understand what has happened to our coastal resources in the past, what their condition is at present and what are the potential impacts for the future. The monitoring plan described in this report is an example of how to develop either the first attempt at monitoring these resources or refine and enhance a monitoring program which already exists.

The remaining sections of this report describe the major steps in designing a monitoring program: collecting background information; defining the watershed; collecting and analyzing existing data bases; designing the monitoring the program; and conclusions and recommendations.

Collecting Background Information

Every scientific study begins with a review of the literature. Designing a monitoring plan is not exempted from this requirement. However, in addition to a review of the scientific literature, designing a monitoring program requires more than the standard search of journal articles. The goal of the literature review for a monitoring program is to find out about everything within the estuary and its watershed. This includes the scientific aspects as well as information on how the area has developed, what alterations have occurred in upland areas what are the present and past land use activities and an account of the entire history of the area.

This essential work cannot be overlooked. The entire basis for designing your monitoring program will depend upon what is already known about the system. If little information is available, then your monitoring program should be designed to provide baseline data which characterize the area, recognize threatening conditions, establish the present degree of regulatory compliance and create a data base for making future comparisons. If considerable information already exists, then develop your program to collect data for parameters on which no data exists, test for environmental changes over time, determine regulatory compliance and recommend, based on the data, new or revised management policies. While the approach to these types of monitoring programs may vary, the literature review is a common starting point.

The review of existing information should cover the estuarine system and its watershed. Five information sources should be reviewed: scientific journals; government reports; "gray literature"; historical documents; and aerial photographs and maps.

The standard review of the scientific literature can be accomplished by visiting a major college library or other similar facility and reviewing appropriate scientific journals. In preparation of this event, develop a list of journals to be reviewed. All types.of scientific journals should be surveyed. The primary types or classes of journals which are likely to contain useful information in the development of the monitoring program, are the environmental, biological, geological and hydrological journals.

Libraries have access to a number of abstract services. If funds are available, you should conduct a computer based literature search. These searches are conducted using keywords based on article content, titles and authors. Thus it is possible to be very specific as to the topics being searched.

During each visit to a library, keep a record of the volumes and issues of each journal that is reviewed. When articles are encountered that will be useful to the program, request a reprint or make a photo copy of the article. These materials will form the basis for an on-site reprint collection. Review of the literature should be an ongoing process. If possible you should plan quarterly library visits.

Once articles relating to the estuary and its watershed begin to accumulate, you can obtain a good secondary source of additional information from the literature citations of the initially collected papers. During this process and in the literature review process as well, some articles from lesser known and available journals will be encountered. Copies of these papers can be obtained using the inter-library loan process. This service is available at most university libraries and through the Department of Natural Resources, Marine Research Laboratory, in St. Petersburg.

As the reprint collection develops, the papers should be catalogued for future use. While the initial review of the literature may reveal a manageable number of papers concerning the study area, this number is certain to increase as additional papers concerning a particular habitat type such as mangroves or seagrasses begin to accumulate. We recommend a computer based cataloging system be developed for the reference collection. Citations for each reference should be entered into a database program.

Keywords should be included as a part of each citation in the data file. With the appropriate software program (eg. d Base III), it is possible to search the reprint collection using titles, authors and keywords to locate specific papers. The list of keywords for the reprint collection can be very detailed and specific to the area. The reference collection for Rookery Bay - Ten Thousand Island area utilized a program written for dBase III Plus. A typical citation is illustrated in Figure 1.

In addition to scientific journals, libraries often contain a variety of government reports. Many government reports are contained in a separate section within the library. Finding reports that are of relevance to your area can be difficult. A computer literature search will reveal some. Citations in journal articles will uncover others. Direct contact with federal agencies (eg. Environmental Protection Agency, National Oceanic and Atmospheric Administration and National Marine Fisheries Service) can be useful. Some agencies have publication lists which are available. Check with a local office or regional headquarters for the availability of these list of publications.

A substantial amount of information concerning the estuary and its watershed is available locally. This information is contained in sources that are referred to as "gray literature." The " gray literature" consists of reports from regional planning councils, water management districts and county or city governments. Often times this literature is not found in major libraries and can only be obtained from having local knowledge of the area. As part of the literature search, local and regional agencies should be queried for information concerning the management area.

Many counties presently have comprehensive plans. These documents are the guidelines for the use and development of land within the county. If plans do not already exist, they will be developed as a requirement of the recent action of the Florida Legislature passing the State Growth Management Act. Depending upon the effort expended by each county, this document can be a valuable source of information concerning land use patterns, water quality, and future directions for the county's development.

Because of Florida's many environmental laws and regulations, there may be substantial information available in grey literature documents such as Development of Regional Impact (DRI) and Planned Unit Development (PUD) reports. These papers often include data from an environmental impact studies of development projects, analysis of subsurface water movement and assessments of wetland and terrestrial habitats. These documents are usually prepared by a developer's consultant. Taken in the proper perspective, they can provide the basis for understanding the biological and hydrological conditions of the estuary and its watershed.

In conjunction with the review of the scientific literature, government documents and "gray literature", emphasis should also be placed on obtaining documents concerning the history of the county. Of particular concern is the history of the development of the county and the history of water management issues. Information of this type is sometimes available in local libraries where books, old newspapers and other historical documents concerning the county may be found. Inquire if historical societies or county museums exist. Often times these organizations have locally written publications detailing early accounts of the county's history. Long-time residents can often provide interesting insights into the area and leads on where to find obscure references.

A essential type of background information that is available for virtually every area in Florida is aerial photographs and maps. Most areas have maps and/or aerial photographs dating back to at least the 1950's. For some areas, photographs are available from the 1920's.

Acquisition of a photograph and map reference collection for the management area is an important part of collecting background information. The images should be a permanent part of the reference collection at the field office. Types of images available include topographic maps, black and white low altitude photographs, high altitude color and infared photographs and satellite images collected by the LANDSAT and SPOT satellites. A list of some of the organizations and agencies from which photographs and maps are available is provided in Appendix 1 of this report.

The collection of background information is the starting point for all monitoring programs. It should also be a continuing part of the monitoring programs. Once the initial information has been collected and contacts with appropriate local, regional and state agencies have been made, the addition of new information will become easier. In many instances, the field staff will be on mailing lists to receive new reports from governmental agencies as they are produced. This type of relationship in combination with regular visits to the library will produce the background information necessary to develop, refine and revise the monitoring plan over the years.

Defining the Watershed

An essential yet difficult task in designing a monitoring program is to define the watershed. Identifying the vegetation patterns, present land uses and natural and manmade features of the watershed are critical since it is from this area that much of the freshwater entering the estuary originates. Understanding the quantity, quality and timing of freshwater entering the estuary is necessary in order to identify the major characteristics of and environmental threats to the estuarine system. (Cross and Williams, 1981)

Prior to the extensive development of Florida's coastal zone and associated uplands, estuaries experienced few of the problems that we deal with today in the management of these systems. As Florida developed alterations to the topography and vegetation occurred. These alterations began what has turned out to be a long and steady change in the quantity, quality and timing of freshwater leaving the uplands and entering the estuarine system.

Mitchell and Mitchell (1980) and Cross and Williams (1981) discuss effects of changes in freshwater flow to estuaries. In their paper Mitchell and Mitchell review the literature and discuss types of effects that estuarine organisms may exhibit as freshwater flows change. These effects include:

1. When freshwater flow is reduced the resulting extreme salinities may determine the distribution of estuarine organisms. This may have long term effects on species distribution.

2. Species, such as saltmarsh plants and bivalve larvae have different salinity requirements at different seasons and stages of life cycle. Changing freshwater flow patterns can alter reproductive success and growth rates;

3. Increased retention time of pollutants and sedimentation rates result as flow decreases; and

4. Increased nutrient levels occur with the input of nutrient enriched waters.

At the same time that the defining watershed is essential, there are difficulties in accomplishing what may be perceived as a relatively simple task. There are two problems in defining the watershed The first is a result of the naturally flat topography of much of the Florida peninsula. A classic example of an easily defined watershed would be a glaciated perched valley. The watershed is defined by the ridge of mountains which enclose three of the four sides of the valley. All rainfall which accumulates within this area flows down the sides of the mountain into the valley and eventually empties into another larger valley.

Florida, for the most part, lacks such well defined physical structures that separate watersheds. Instead, a relatively uniform and gently sloping topography exists along the coastal portions of the state. While a defined watershed still exists it is difficult to accurately assess the exact boundaries since a change of a few inches of elevation can make a difference between water flowing into one shallow watershed versus another.

This problem is further compounded during the wet season when some watersheds, separated by extremely low ridges, merge as surface water accumulates at a level higher than the natural ridge separating the two watersheds. Thus, for many watersheds temporal variation plays a significant factor in determining whether you are dealing with one watershed or a series of merged watersheds.

The second difficulty encountered in defining a watershed is a result of extensive development activities which have altered natural watersheds. Changes brought about by canal dredging have resulted in excessive draining of the uplands. Roads have unintentionally acted as dams to sheetwater flow. Large agricultural areas redirect water through irrigation practices. Surface water runoff is increased when permeable soils are covered by houses and parking lots. The presence of these alterations has changed the shape of and size of watersheds.

Often it is difficult to assess the effects of these changes. Thus, what has been considered in the past as one watershed may now be divided into several watersheds and what may have been several natural watersheds may now be one large watershed. Virtually all watershed boundaries in Florida are artificial since there are no areas in the state that have not been affected by road or drainage canal construction, agricultural practices and residential and commercial development.

Since many areas of Florida that are presently developed were originally wetland areas or low upland areas, most contain some sort of structures to convey water from the land during periods of high rainfall so that the land remains dry and usable. Most often, these structures are drainage canals. An accurate map of the locations of these structures, the date when they were constructed and data concerning the amount of discharge that occurs on a yearly and seasonal basis is needed. Studying existing information and monitoring new data will help assess the potential for impacts to the system as the quantity and timing of freshwater entering the estuary changes.

Roads within the watershed have an opposite effect from canals. Usually these roads lack culverts and serve as dams to freshwater flows. If enough roads are present, some upland areas may become impounded. After an initial survey of road locations are noted, the presence of major culverts within these road systems should be noted on a map. As was the case with the drainage canal system such information is useful in assessing what alterations have occurred to the quantity and timing of freshwater entering the estuarine system.

Land use patterns within the watershed must be examined. Locating agricultural, commercial and residential areas will assist in determining which parameters should be monitored. For instance, more emphasis may be placed on monitoring for nutrients and pesticides in an intensely agricultural watershed whereas monitoring for heavy metals and industrial type pollutants would be more important in an urbanized watershed. In addition to the analysis of land use patterns you need to locate potential point source and non-point source discharges. The type of monitoring program designed will, in part, depend upon whether the program is to monitor for point source or non-point source impacts on the estuarine system.

A thorough knowledge of the vegetation patterns within the watershed and estuary is also necessary. Through vegetation patterns, the location of freshwater wetlands can be located. Because these areas are the conduit for fresh water to reach the estuary these areas should be identified and given special consideration as preservation areas as the watershed is developed.

Detecting changes which occur over time in the amount and type of vegetated areas is useful in assessing the current status of the estuarine system and watershed, the threats to these areas and the type of monitoring to be conducted. A considerable amount of estuarine wetland classification work is being done through the Department of Natural Resource's Marine Research Laboratory and Department of Environmental Regulation's programs using LANDSAT images. Eventually, this work should be expanded so that each aquatic preserve has a LANDSAT survey and baseline vegetation map of the entire estuary and watershed.

The watershed that is defined for the monitoring program should use the artifical boundaries. The land within this area is most likely to contain alterations and point source discharges that will directly impact the estuary and therefore affect management problems. It is also helpful to define the natural boundaries (historical boundaries) of the watershed. Comparative information on the natural and modified watersheds is useful in assessing whether restoration activities are an appropriate and viable management alternative.

There are three potential sources for information concerning the watersheds of the coastal systems of Florida. The U.S. Geological Survey (USGS) has designated all portions of the state of Florida as belonging to the specific "hydrologic units." These are large areas within the state which generally contain a number of subunits. For information concerning the hydrologic units within the study area, contact the U.S. Geological Survey Reston, Virginia 22092. In the inquiry to the USGS, request additional information that may be available about the study area. Some publications do exist. For example, the U.S. Fish and Wildlife Service has done an ecological characterization of the Caloosahatchee River/Big Cypress Watersheds in Southwest Florida (Drew and Schomer 1984).

More detailed descriptions of the subunits within these major watersheds are available from the local water management districts and/or county government offices. In researching the watershed units within the Ten Thousand Islands area, we discovered that the Collier County Comprehensive Plan (1983) contained maps of drainage basins which closely approximate naturally occurring watersheds within Collier County. However, because of extensive development in this area these basins were not sufficient to define the watershed of primary concern in managing the Cape Romano - Ten Thousand Islands area.

Further research through the Water Management District office revealed three documents about subwatersheds within the natural basin areas described by the County (Master Plan for Water Management District No. 6 1972; Belle Meade-Royal Palm

Hammock Water Management Plan 1982; and Master Plan Update for Water Management District No. 6 1985). These reports contain detailed information about the watersheds that are specific to the Rookery Bay and Cape Romano areas.

Acquiring and Analyzing Existing Databases

Simply gathering information and organizing it is insufficient. Before you can design a monitoring program the data from the literature review and characterization of the watershed should be integrated and reviewed. Conclusions about the present status should be derived. Depending upon the system being studied, this can be a relatively easy task if little information is available or it can appear to be a monumental task that will take years to accomplish. In the latter case it is not recommended that all data from a large estuarine area (eg. Tampa Bay) be acquired, synthesized and analyzed. Instead only the specific subestuary and subwatersheds within this large area should undergo this close scrutiny.

Evaluation of the available data and what the analyses of these data tell us about the system provides the final details necessary to design a monitoring program. The evaluation process provides an assessment of gaps in the existing database. It will also help to determine station location and sampling frequency for the monitoring program.

Data acquired from previous work should be entered into a computer data base program. In order to create this data base the raw data from each study should be acquired. In tandem with this request it is essential to obtain a detailed account of the methods by which each data set were collected, analyzed, and summarized. Usually, this information is contained within a written report. Without knowledge of how samples were collected and analyzed, interpretation of the data from different studies may lead to erroneous conclusions if the data were collected or analyzed via different methods. If this is the case it will be necessary to determine whether or not the data can be compared for purposes of assessing the system. If in doubt, we recommend consulting with the author or authors of the various reports.

As data sources are acquired, a computer data base should be established for the study area. We recommend establishing a master data file (all parameters) and separate data files for each parameter on which information is available. Thus, as you accumulate reports containing salinity data, the data can be entered into a salinity data file and master data file in the computer.

When all information has been collected, an initial data analysis using descriptive statistics should be conducted. The purpose of this is to examine the pattern or patterns in the data over time and/or between sample locations. For the entire data set it may be appropriate to perform other statistical tests such as correlation coefficients and analyses of variance or covariance. These procedures will provide insights into possible relationships between one or more of the variables.

Unusual changes in the behavior of a parameter should be examined in relation to unusual changes in the land use pattern in the watershed. For example, increased turbidity levels may be observed when a pine forest was cut and burned and the land converted to agricultural use. Or increased nutrient levels may be found when a new sewer plant was built and began discharging into a major tributary of an estuarine system.

The acquisition and analysis of data collected by others may be the major source of data for your monitoring program. It is possible, although less desirable, to conduct analyses of data collected by others and synthesize the results to produce a ongoing monitoring program for the study area. A monitoring program of this type is less than ideal but it is better than no program at all.

The importance of the preliminary work described above cannot be over emphasized. Any monitoring program that is not based on a review of existing information and knowledge of the watershed will never do more than provide limited information.

Designing a Monitoring Program

There are four elements to be considered when designing a monitoring program: choosing the parameters to be monitored; determining the frequency at which samples will be collected; determining the station locations; and conducting a data analysis (Thoemke 1986) with the exception of conducting a data analysis the first three tasks are collectively done. For purposes of discussion each element will be separately discussed.

Choosing Parameters to be Monitored

A review of the scientific information on estuaries shows that there are many parameters and groups of parameters that have been studied at one time or another. For purposes of designing a monitoring program these parameters can be grouped as physical, chemical and biological. We will assume that the budget constraints imposed on the choice of parameters have been accounted for.

While there are many physical parameters. which could be monitored the core group of parameters which should serve as the backbone of the monitoring program include temperature, salinity, pH, dissolved oxygen, turbidity, rainfall and tidal level. If it does not exist, a long term data base should be collected for these parameters.

The core group of parameters are good indicators of what is occurring within the system. Salinity is the most critical parameter within the core group. Although estuarine areas are characterized by fluctuating salinities during the course of a year, the naturally occurring cycle is predictable. Estuarine salinities increase as freshwater input decreases and decreases when freshwater inflow increases. Because many estuarine organisms depend upon a certain salinity range to complete their life cycle, deviations from the expected normal ranges are indicators that either a natural or man induced change is occurring within the system. Hines et al (1987) discusses the importance of a long term salinity data base. Variations in temperature are usually predictable based on the time of the year. Fluxuations in the pH are usually definable for the same reasons outlined for changes in salinity.

Dissolved oxygen values fluctuate over a wide range within the estuary. They are related to both the temperature and salinity of the water. Extreme low values of DO serve as an indicator of poor estuarine health. Turbidity is highly variable throughout estuarine systems in Florida. The degree of turbidity depends on suspended materials that enter the estuary via freshwater inflow and resuspension via wind and tidal action. Elevated turbidities can surpress phytoplankton growth and survival of submerged aquatic vegetation.

The equipment for measuring temperature, pH, salinity and dissolved oxygen should be designed of measuring these parameters in situ. Readings should be taken at the surface and bottom. Stratification in any of these parameters should be recorded and nutrient samples (discussed below) should be taken in each layer. Physical parameter data for the Thousand Islands study (temperature, salinity, pH, and dissolved oxygen) were collected with a Hydrolab (Model 4083). While these parameters can be measured with other instruments, the ease and convenience of measuring all parameters in one overboard probe was found to be time saving. If the instrument is properly calibrated and handled, it has proved to be very accurate during field sampling. In addition to these physical parameters, a small bottle of water should be collected for laboratory analysis of turbidity.

Rainfall and tidal level data are important parameters to measure in the core group. Both the amount of rainfall within the estuarine area and watershed and tidal fluxuations will be useful in relating changes in salinity, pH and dissolved oxygen to the rainfall events. If one or more tide gauges are not already present in the area, at least one tide gauge should be installed. If one or more rain gauges are not in place, then at least one recording rain gauge should be installed. Because of the tropical rainfall pattern of rainfall in Florida, it is not unusual for part of the watershed to receive a different amount of rainfall compared to a relatively close area. For this reason, we recommended that more than one rain gauge be installed within the watershed. Prior to deciding how many rain gauges should be placed within the watershed, check with the National Weather Service, airports, Water Management District Offices, County Government Offices, Mosquito Control Districts and agricultural facilities to assess the location of existing rain gauges.

Chemical parameter data are the second type of information for which baseline data should be obtained. The parameters included in this group are ammonium, nitrate and orthophosphate. Nitrogen and phosphorous represent the important classes of dissolved inorganic nutrients which occur in the water column. These nutrients are essential for primary producers. Levels of dissolved nutrients within the system serve as an indicator as to the degree of organic enrichment of the system. The purpose of collecting baseline dissolved nutrient data from the water column is to determine whether nutrient enrichment is occurring within the study area. If station locations and sampling frequency are properly designed you may obtain strong indications of where the source of nutrient input is located.

Monitoring of dissolved nutrientsis not intended to detect changes in nutrient levels between the water column and the sediments or provide a detailed analysis of nutrient cycling within the system. A more rigorous research project is necessary to obtain this information. The results of the nutrient monitoring should suggest types of further scientific research on nutrient cycling that should be conducted within the area.

Sample analyses for the pilot study of the Ten Thousand Islands for nutrients were conducted using the methods of Strickland and Parsons (1972) and Parsons et al (1984). The technique was slightly modified so that a microtechnique could be used (Carlson, personal communication). Sampling procedures are provided in Appendix II.

During the planning stages for this project both the water chemistry laboratory of the Florida Department of Environmental Regulation and the U.S. Environmental Protectional Agency Laboratory were contacted concerning availability of a standardized and approved method of nutrient analysis for estuarine water. At present no such standards or certification exists. We recommend the Department of Environmental Regulation develop these standards. Results of analyses from a certified lab will be less questionable in legal cases and would be better received during the rule making process of regulatory agencies.

While obtaining baseline data for these parameters is highly desirable we recognize that nutrient analyses require specialized equipment. We do not recommended each facility or aquatic preserve have the equipment to analyze nutrients. This is not cost or time effective at this stage of the Aquatic Preserve program. We recommended that one or more regional water chemistry laboratories be established within the aquatic preserve system. Each facility would provide analytical work for several aquatic preserves.

As a part of this grant such a facility has been established at Rookery Bay. The equipment purchased with funds from this grant is capable of conducting nutrient analyses. With a full time technician the present capacity for processing samples for the nutrient parameters discussed in this report is 300 complete nutrient samples per week.

Monitoring biological parameters is more time consuming and expensive than monitoring physical and chemical parameters. In addition it requires a specific expertise in one or more groups of estuarine organisms. Consequently monitoring or designing a monitoring program for biological variables must be approached cautiously. If the study area has no data concerning biological parameters, we recommended to first develop a comprehensive species list for the area. Ideally this list should include information on the density and distribution of each species.

Particular attention should be devoted to identifying any organisms that are known to be indicators of water quality problems. If these organisms (bioindicators) can be identified, then emphasis on their abundance and distribution should be studied.

Long term monitoring of bioindicators is an effective method of monitoring the long term effects of pollution on a system (Segar et al 1987). One group of organisms that have received considerable attention are bivalves. Farrington et al (1987) discussed the use of bivalve species as bioindicators for monitoring the levels of some chemicals in the estuarine environment.

While recent papers and literature such as those noted above emphasize the importance of biological monitoring, this type of monitoring may not be of primary importance for some Florida estuaries. In areas such as Rookery Bay and the Ten Thousand Islands where the estuarine watersheds have not been severely impacted by industrial or extensive agricultural runoff, factors such as the quantity and timing of fresh water entering the estuarine system are more important management concerns. In these areas biological monitoring, which is extremely time consuming, is not recommended as part of the initial monitoring program. However if a sufficient database of physical and chemical data are available then a plan to monitor selected groups of organisms should be planned.

For some systems, special parameters should be monitored. Areas that have industrial discharges or extensive agricultural activity should consider baseline sampling for pesticides and heavy metals in the water column, sediments and or tissues of organisms such as oysters, clams and mussels. Because of the highly specialized equipment necessary to detect these compounds, arrangements for analysis must be made with a well equipped laboratory at a major university, private laboratory or state laboratory. Initial analysis for Rookery Bay was contracted with the Water Chemistry Laboratory, Department of Health and Rehabilitative services in Jacksonville. (Thoemke and Gyorkos 1987)

Determining Sampling Frequency

The second factor to be considered when designing a monitoring program is the frequency at which samples are collected. As was the case in determining which parameters to monitor this question is also influenced by the funds and staff available.

When dealing with sampling frequency there are two scales of concern: short term temporal variation such as over a tidal cycle and long term temporal variation such as over the course of a five year period. For purposes of designing a monitoring program it is impractical to deal with a long term database that is monitoring to detect short term temporal variations. Rather, a long term study should involve determining long term temporal variations (Hines et al 1987).

Based on our previous work (Thoemke and Gyorkos 1987) and the sampling program developed for the Ten Thousand Island, we recommend the core group of physical parameters be sampled at a interval not exceeding every other week. Weekly sampling is preferable. Samples taken less frequently than this may not accurately represent the range of annual variation. Nutrient samples should be collected at a frequency not to exceed one month intervals. Biological samples should be collected at intervals not exceeding four times per year. While these sampling frequencies may seem inadequate it is important to remember that data will be collected over a multiyear period. The data are intended to describe long term distributions and concentrations. Sampling at frequencies that are used in short term studies (1-3 years) would be preferred but is not realistic given the man power and budget of the Bureau of Aquatic Preserves at this point in their history.

There is one exception to the sampling frequency described in the preceding paragraph. There should be increase in the frequency of sampling during periods of extreme events. This would include storm and drought events. Hines (et al 1987) and Mitchell and Mitchell (1980) have discussed the importance of extreme events on the distribution of estuarine organisms. During these unusual occurrences sampling frequency should be increased in order to detect at what levels and duration the changes occur during this event. Extreme events probably control the distribution of estuarine organisms more than any other factor.

Additional detailed discussions concerning sampling frequency are provided in Boyle (1987) and Green (1979). Both references should be consulted when planning a monitoring program.

Determining Station Locations

The third element of designing a monitoring program is determining the station locations. A number of factors will influence this decision. In addition to the obvious concerns of manpower and funding, station locations should be determined based upon the analysis of the existing database. From the background information collected about the area, station locations should be chosen to correspond to any previously designated sampling area from which there is a significant amount of data. This will facilitate the comparison of data collected in the monitoring program with previously collected data. The same consideration should also be given to the frequency at which the data is collected.

Particularly desirable station locations include the mouth and one or more upstream sites of tidal channels and drainage canals, the tidally connected openings of estuarine bays and lagoons to oceanic waters and stations along a salinity gradient if other than previously described. Sampling along a salinity gradient allows for data analysis using the conservative mixing model (Barton and Liss, 1976) described in the data analysis section of this report.

Designing an effective monitoring program for an estuarine area may necessitate sampling areas at the headwaters of the estuary or into some of the freshwater regions. Because of the importance of the freshwater within the estuaries watershed, it is appropriate for monitoring activities to extend into the upland portion of the watershed.

Station locations in the Ten Thousand Islands were chosen in the headwater bays, channels and Gulf front channel openings of the study area (Figure 2). These stations also corresponded to seasonal salinity gradients which occurred during the rainy season months.

Green (1979) discusses the importance of taking randomly allocated replicate samples. Sampling areas (i.e. station locations) that are chosen for the monitoring program should be large enough to allow the collection of random samples within each sampling location. They should not be so small as to allow for only a single discreet sample station to be chosen. A complete discussion on the philosophy and rational for choosing station locations is beyond the scope of this report. The reader is referred to Green (1979) for a more detailed discussion on choosing station locations.

Data Analysis

Once data have been collected it is important to analyze the results and make interpretations about the system. Keeping in mind that this is a monitoring program and not a scientific study, a detailed statistical analysis is not required. Descriptive statistics such as the mean, standard deviation and variance are the first level of data analysis that should be conducted. These results should be presented in either graph or table form depending upon the amount of data to be presented.

The analysis of the data using a correlation coefficient matrix is also very useful. Correlation coefficients express the amount of relationship and dependence of one variable on another. Usually this is interpreted as one parameter controlling or regulating by another. This information can be very useful in inferring what types of management problems exist within the estuarine area. For example, a high correlations between elevated dissolved nutrient levels and low salinity suggests that nutrients are coming from an upland source.

If sampling stations are located along a salinity gradient the behavior of the dissolved constituents in relation to changes in salinity can be analyzed using the conservative index of mixing (Burton and Liss 1976). In a conservatively mixed estuary the concentration of a constituent (parameter) will exhibit a linear variation along a salinity gradient. If the concentration of the constituent varies from the linear relationship it indicates either the addition or removal of that constituent from the system (Figure 3). Extreme deviations from the theoretical dilution line in a narrow salinity range would indicate the addition or removal of a constituent (Figure 3). Data analyzed in this fashion can provide strong inferences as to the location of potential point and non-point source discharges of pollutants to the estuary.

It is likely that after a few years your monitoring program will be dealing with large amounts of data. This makes the use of a personal computer with spreadsheet and data base software program essential. A data file for all parameters should be established. In addition a separate data file for all information on individual parameters should be created. Assuming that the data in your monitoring program was collected using compatible methods, you can merge your data set with the historical data sets from other studies.

Data analysis and the presentation of results from biological monitoring will vary depending upon the type of or group of organisms being sampled. Benthic invertebrate and fish data should be analyzed for average number of individuals per sample, total number of species per sample, the density or unit of area, the average size per species, the sex ratio and presence of area, the average size per species, the sex ratio and presence of egg bearing females. In general, any life history parameter that can easily be collected as part of the sampling program should be noted.

After data have been analyzed and the results interpreted, the final step in the design and implementation of the monitoring program should be to prepare reports summarizing what has been learned about the area. At least three types of reports should be prepared. If sufficient information exists, a separate summary report of previously collected data should be completed. Second, yearly summaries of the results of the monitoring program should be prepared. These will function as periodic reviews of the data so that any changes which may be occurring in the system can be described.

The third, and most time consuming is a comprehensive report of all the data known about the system. The synthesis should contain easily interpretable graphics and concise summaries for each parameter on which data exists. A general discussion should follow which interprets the results and relates their meaning to the past, present and future management of the system. The summary report prepared for the Apalachicola system (Livingston, 1980) is the type of synthesis and summary document which should be prepared for each Aquatic Preserve.

Periodically a revaluation of your monitoring program and management plan should be conducted. The results of previous and current studies will reveal ways in which to update and enhance the monitoring program as well as provide the information necessary to analyze and if appropriate, revise the management objectives and policies of the study site. Thus, this entire process is part of a self feeding loop that goes on indefinitely.

Monitoring Program Duration

Once a sampling program has been planned, the program should be continued for a minimum of three years. Ideally the program should continue indefinitely. However given the realities of funding long term monitoring programs it is unlikely that data can be continuously collected. We recommend the Aquatic Preserve Program change this policy by providing sufficient staff and funds to maintain an ongoing basic monitoring program. As a minimun this should include monitoring the core group of physical parameters: temperature, salinity, pH, dissolved oxygen, turbidity, rainfall and tidal level.

The other data sets: nutrients and biological parameters should be collected for an initial period of at least three years. This amount of time is necessary to establish whether the annual cycles observed are representative of typical years. If budget and staff constraints do not permit continous monitoring we recommend altering nutrient and biological monitoring programs, sampling nutrient on even years and biological parameters on odd years for example. Over the long term this should provide satisfactory information concerning long term changes and behavior in the parameters being studied.

The Cape Romano-Ten Thousand Islands Aquatic Preserve Study

Using the procedures outlined in this report a baseline monitoring program for the Cape Romano-Ten Thousand Islands Aquatic Preserve has been initiated. The background search revealed several references but comparatively little scientific data about the system. The size of the watershed was determined from documents obtained from the Collier County Comprehensive Plan (1983). A vegetation analysis of the estuarine area was conducted using a LANDSAT image and ERDAS software.

A review of the information available on this system resulted in choosing the sample stations located along salinity gradients indicated in Figure 2. Sampling was initiated in April, 1987 at 14 stations. Samples are collected every 2 weeks. The parameters for which data are being collected include: temperature, pH, salinity, dissolved oxygen, secchi disk readings, turbitity, BOD, suspended solids, ortho phosphate, ammonium, nitrite, nitrate, chlorophyll a, b and c and phaeopigment. The insitu parameters are measured with a Hydrolab (Model 3038). Laboratory analysis of turbitity, BOD, and nutrient and chlorophyll analyses are conducted using an Orionoxygen probe and incubation box, HF turbidity meter and Perkin Elmer spectrophotometer respectively. Methods for laboratory analysis are contained in appendix II. Appendix III contains the raw data through September 1987. Due to the incomplete data set, an analysis has not been conducted. Sampling will continue into April 1988 at which time a preliminary report of the results of the data from the first year will be prepared. This report will contain the literature search and information concerning the watershed.

Summary and Conclusions

The recommendations and design for a monitoring program for Aquatic Preserves made in this report are based on our previous experiences and new information learned from this study. Some difficult decisions concerning the type of parameters to be monitored and the frequency at which data should be collected must be made. This report should be considered as a first attempt at designing a monitoring program for the Aquatic Preserves that takes into account current thinking on designing monitoring programs, the staff and funding available for the Bureau of Aquatic Preserves and the amount of information that is available for each site.

The conclusions and recommendations of this report are summarized as follows:

1. A monitoring program is need for the aquatic preserves.

2. The goal of this program should be to assess the status of the system and provide data for management policy and decision making.

3. The questions which the monitoring program should attempt to answer are: What is the present status of the area, is the area being stressed, and are the present management policies effective in dealing with management issues?

4. The first step in designing a monitoring program is to collect background information about the system. This

information should include a review of the scientific literature, government reports, gray literature, historical accounts and available maps and photos.

5. Field offices for Aquatic Preserves should establish a computerized reprint collection for background information.

6. The boundaries of the Aquatic Preserves watershed must be defined. Information concerning the quantity, quality and timing of fresh water entering the estuary, land use and vegetation patterns of the watershed must be determined.

7. Careful consideration must be given to defining the watershed since most areas in Florida have been affected by the construction of roads and canals and upland residential and commercial development.

8. Help is available from the U.S. Geological Survey and Water Management Districts in defining the watershed.

9. When all background information has been acquired an initial analysis of the data set should be conducted in order to determine the type of parameters to be monitored and how the data should be collected.

10. The background data uncovered during the discovery phase should be entered into a computer data base for future analysis with the data collected from your monitoring program.

11. Designing a monitoring program involves four elements: Choosing the parameters to be monitored, determining sampling frequency, determining station location and conducting an analysis of the data. A core group of physical parameters is the minimum data set for the monitoring program. Ideally these data

should be continuously collected.

12. Dissolved nutrients should be sampled to determine if enrichment problems are occurring. Nutrient enrichment is a major source of estuarine habitat degradation.

13. Biological data should be collected after an initial physical and chemical data have been obtained. When conducting biological monitoring, bioindicaters species should be identified.

14. Sampling frequency for the core parameters should be an interval not greater than 2 weeks. Nutrient sampling should be at an interval not greater than one month. Biological sampling should not be at an interval greater than 4 times per year.

15. Intense sampling of the system should be done during extreme events.

16. Station locations should be based on establishing stations along a salitity gradient and include sites where data were collected in previous studies.

17. Data analysis should be limited to descriptive statistics, correlations and conservative versus nonconservative mixing models.

18. The duration of the initial monitoring program for an aquatic preserve should be a minimum of three years.

Finally we recommend the Bureau of Aquatic Preserves provide sufficient staff and funding to conduct a basic monitoring program for all aquatic preserves as outlined in this report. Successful management of these systems depends upon having an understanding of the physical, chemical and biological conditions within the preserve. This information is best obtained from a monitoring program. The results of the monitoring program will be used to specify research that addresses specific management questions. In turn this information will enhance the monitoring program via a feedback cycle between research and monitoring.

The results of monitoring program will also be valuable for the education program of the aquatic preserves. The results of both monitoring and research can be directly used in educating the public and professionals concerning the problems of the preserve and whether the management policies in effect are dealing successfully with the problems.

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CAT NO.	749
AUTHORS	OSTRY, ROBERT C.
DATE	1982
TITLE	RELATIONSHIP OF WATER QUALITY AND POLLUTION LOADS TO LAND USES IN ADJOINING WATERSHEDS
SOURCE	WATER RESOURCES BULLETIN, VOL. 18, NO. 1
KEYWORDS	WATERSHED, WATER QUALITY, POLLUTION SOURCES, URBAN RUNOFF, POINT SOURCE, AGRICULTURE RUNOFF

Figure 1. Typical citation from dBase III computer library system.

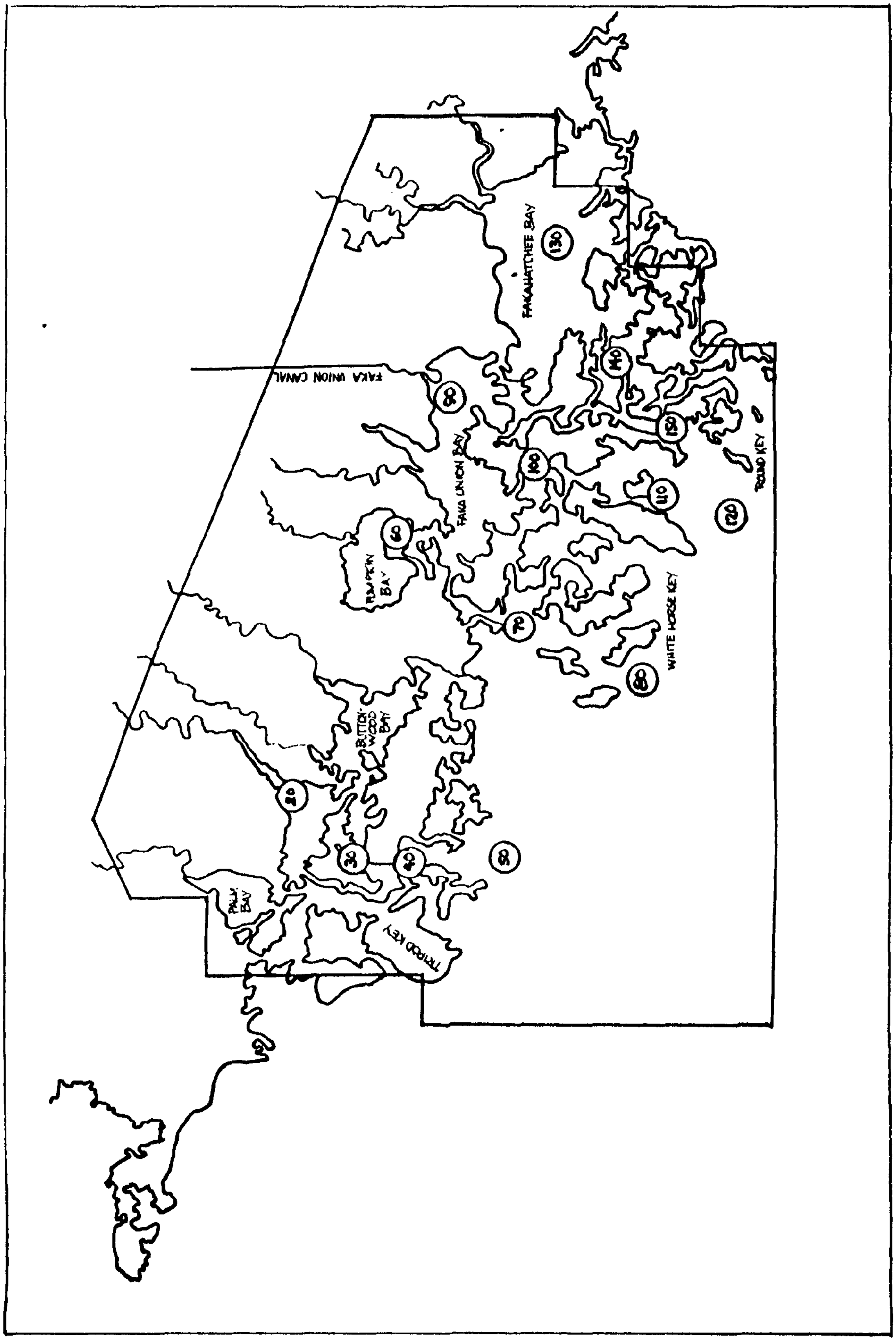

Figure 2. Station location for the Ten Thousand Island Aquatic Preserve area.

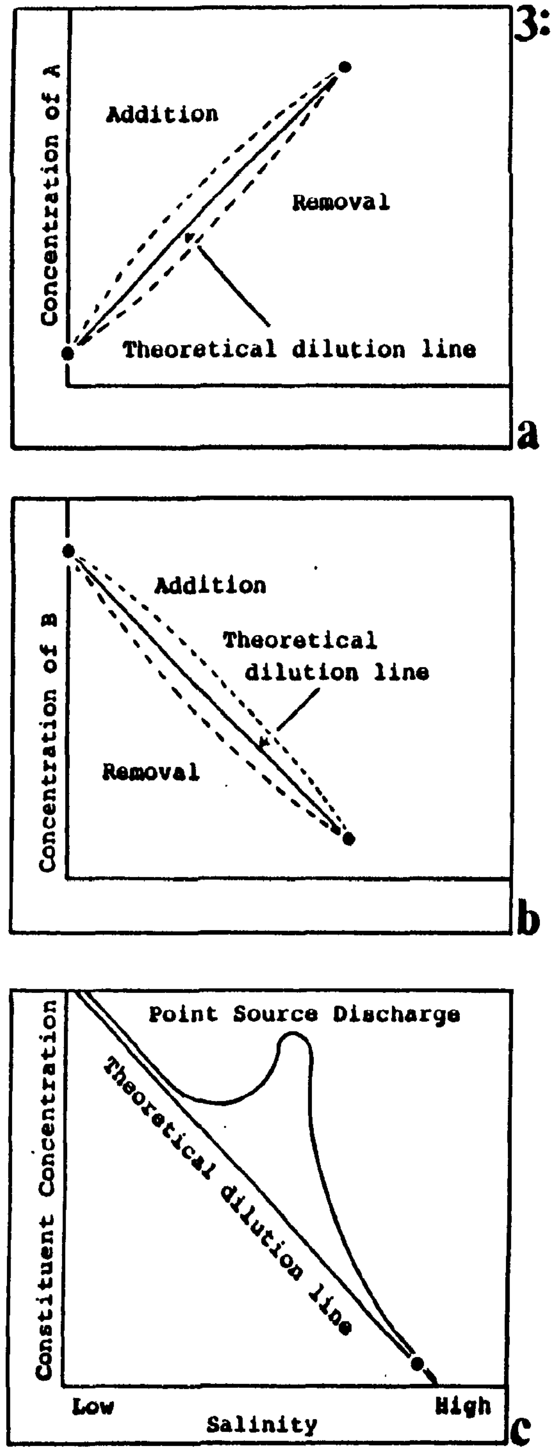

Fig. 3. Idealized representation of the relationship between concentration of a dissolved component and a conservative index of mixing, for an estuary in which there are single sources of river and sea water: (a) for a component (A) whose concentration is greater in sea water than in river water and (b) for a component (B) whose concentration is greater in river water than in sea water. (Redrawn from Burton and Liss. 1976). (c) Idealized representation of a point source discharge.

Appendix I. Sources of Maps and Aerial Photographs.

1. local government -

Several types of maps are available from your county government offices. The types found for Collier County include engineering , REDI , county development , and composite maps. In addition the county's Natural Resources Management Department has a complete set of aerial photos. Local government offices are a good place to start looking for information.

2. U. S. Geological Survey (USGS) -

Many aerial photographs and maps have been compiled, and area indexed and stored on microfiche with the USGS. Using this source you may order maps and photos from the early 1950's to the present. This is a good agency to use which may save many hours of searching other less inclusive sources.

US Geological Survey
National Cartography Information Center
507 National Center
Reston, VA 22092
(703) 860-6167

3. United States Department Agriculure -

The United States Department of Agriculture has an extensive collection of aerial photography. To order images send a map of area with the preserve location illustrated and a description of the size and type of image needed. Photographs are available from 1952, 1953, 1963, 1980, and 1982 - 1984 in two sizes. Black and white image are $ 3.00 for a 9"x9" and $ 12.00 for a 24"x24" image.

Aerial Photography Field Office, ASCS-USDA

2222 West 2300 South, PO Box 30010, Salt Lake City

801-524-5856

Frank Mackeletere is the contact person

4. National Cartrography Information Center -

Aerial photographs are indexed on the Summary Recode System, a listing of photographs available from government and private sources.

NASA

Slidell, Ms.

601-688-3541

Hank Svehlak is the contact person

5. National Oceanic and Atmospheric Administration -

From this agency you can obtain information from the Office of Satellite Operations, Satellite data processing, National Climatic data center, Oceanographic data, Geophysical data, and Assessment and information services.

Office of External Relations

Information and Communication Unit

E/ER3 NESDIS, NOAA

Room 3308, FB-4

Washington, D.C. 20233

6. Department of Natural Resources, Marine Research Laboratory -

This agency has been involved in preparing base line vegetation maps for the aquatic preserves using satellite imagery. Satellite imagery can be ordered from the two sources EOSAT or SPOT. The first source uses a satellite capable of analyzing 30 meter pixel images and SPOT data has 10 meter pixel resolution. The latter however does not determine differences in vegetation as well as the EOSAT images. Processing of raw data from a satellite image must be done on a mainframe computer that also has personal computer system capabilities. Purchasing an image is expensive and cost will be a major factor involved in the decision to use this type of information. The imagery utilized at the Rookery Bay office is recieved and processed by the Department of Natural Resources Marine Research Lab in St. Petersburg, Florida. We recommend you contact the lab prior to using a satellite image.

Florida DNR Marine Lab

100 8th Ave SE

St. Petersburg, Fl. 33701

(813) 896-8626

Ken Haddad is the contact person.

Specific questions and information can be obtained from:

EOSAT

4300 Forbes Blvd

Lanham, MD. 20706

(800) 344-9933

SPOT

1897 Preston White Drive

Reston, Virginia 22091-4326

(703) 620-2200

7. Florida Department of Agriculture -

This agency can supply aerial photos of most areas of the state. They come in the form of contact prints form for the older sources and index sheets for the newer photos.

Agriculture Stabilization Conservation Service

PO Box 670

Gainsville, Fl. 32602

904-372-8549

the contact person is Ronnie Keller

8. University of Florida -

State universities are a good source for maps and aerial photographs. Larger schools have full service libraries that can handle map listings or are familiar with locations of such listings. The University of Florida has a map library with extensive holdings and can order maps not in the library's files.

University of Gainsville Library

Gainsville, Fl. 32602

(904) 392-0341

Helen Armstrong is the map librarian

Appendix II. Field and Laboratory Procedures.

1. Nutrient Parameters - Triplicate samples were collected from each location at mid depth using a horizontal water sampling bottle . The samples were filtered in the field using a 50 ml syringe and a Gelman 25mm filter holder containing a 25mm Gelman 0.45um membrane filter. The filtrate was transfered to an acid washed and nano pure water rinsed 15ml polystyrene screw cap centrifuge tube. Special care is needed when handling the tubes. Touching the rim or inside of the tube with your hands or fingers will contaminate the samples and result in inaccurate readings.

The tubes were stored in the dark and on ice until returned to the lab. The samples were frozen until processing could be completed. Analysis of the samples was always completed within two days of collection.

Analysis of the nutrient samples was conducted using the procedures of Strickland and Parsons (1972) and Parsons et al. (1984). The volumes used in these analysis were reduced by a factor of 10 for all blanks, samples and reagents. These micro procedures were recommended by Paul Carlson at the DNR Marine Lab in St. Petersburg, Fl. Reduction of sample and reagent volumes also requires the cadmium columns for nitrate reduction be reduced in size. A 5cc syringe was used for the reduction procedure. The reduction of samples and reagents results in considerable savings of time and money.

2. Biological Oxygen Demand (BOD) - Samples were collected at mid

depth using a horizontal water sampling bottle. Standard BOD bottles were carefully filled in the field and stored in a cool ice chest. The initial and five day dissolved oxygen levels were read in the lab with a Orion O meter to determine oxygen uptake by non-photosynthetic organisms.

3. Suspended Solids - Samples were collected in the field with the horizontal water sampling bottle, placed in 250ml opaque Nalgene bottles and kept in a cool ice chest. Upon return to the lab each sample was filtered onto preweighed Whatman glass fiber filters and dried in a Blue M oven at 50 C after drying the filter papers were reweighed. Particulate (suspended solids) weightwas determined by subtraction. Samples may be refrigerated and analyzed up to seven days later.

4. Turbidity Samples - A sample from the suspended solid sample bottle was taken to and analyzed using an Hf Instruments Turbidity Meter.

Appendix III. Raw data for Ten Thousand Island study.

ST20	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1739	1.7	0.4	26.29	7.76	6.62	51	0.719	33.5	11	0.365	0.395
				26.35	7.72	6.17	51	0.205	33.5	40	1.6133	3.51
CTAPR29	1413	1.2	0.5	25.61	7.44	6.62	56.2	0.225	37.4	2.5	-0.406	0.196
				25.49	7.43	6.14	56.4	0.22	37.4	2.3	-0.203	0.275
CTMAY13	ABORT											
CTMAY27	1706	1.4	0.6	28.61	7.71	6.83	47.8	0.234	31.1	4.1	0.9271	0.22
				28.57	7.67	6.78	47.8	0.229	31.1	9.2	0.9563	0.28
CTJUN10	ABORT											
CTJUN24	1553	1.2	0.6	32.79	7.58	5.94	49.2	0.155	32.2	2.4	1.2118	0.621
				32.76	7.57	5.78	49.4	0.153	32.2	4.4	1.5257	0.525
CTJUL23	1553	1.2	0.6	32.79	7.58	5.94	49.2	0.155	32.2	3.8	0.7081	0
				32.76	7.57	5.78	49.4	0.153	32.2	9.8	0.5621	0
CTAUG6	1246	2.2	0.5	32.4	7.51	5.24	46.5	0.152	30.2	9.4	0.219	0.413
				31.94	7.51	4.3	47	0.151	30.4	0.2	0.1533	0.325
CTSEP2	1231	1.8	1	31.51	7.29	3.41	38.6	0.136	24.6	15	-0.1771	0.564
				31	7.36	2.82	43	0.132	27.8	5.8	1.26	0.822

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0.015	0.0203	0.0111	0.7438				
CTAPR29	0.044	0.0174	0.0103	0.724	0.6423	18.2065	22.6204	-3.4313
CTMAY13	ABORT							
CTMAY27	0.013	0.2627	0.0116	0.732	0.1625	3.4733	1.6087	2.3019
CTJUN10	ABORT							
CTJUN24	0.6226	0.004	0.1773	-1.1401	0.5233	10.8776	14.5996	10.7045
CTJUL23	0.007	0.0204	0.0377	7.8589	0.3898	4.6831	6.1036	10.4991
CTAUG6	0.0268	0.0311	0.0244	1.6744	1.1279	31.2339	40.0499	30.7625
CTSEP2	2.0869	0.2032	0.2111	-1.7066	1.0131	23.2553	29.7278	20.5174

ST30	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1728	2.2	0.4	25.26	7.81	6.7	52.8	0.207	34.8	30	0	0.462
				25.27	7.79	6.26	52.8	0.204	34.9	9	0	0.426
CTAPR29	1401	1.4	0.3	24.62	7.54	6.96	56.4	0.256	37.5	7.2	0	1.524
				24.63	7.54	6.53	56	0.245	37.5	3.4	0	0.098
CTMAY13	ABORT											
CTMAY27	1644	1.6	0.6	27.37	7.7	6	49.8	0.24	32.1	1.1	0.7884	0.219
				27.37	7.69	5.72	50	0.232	32.8	6	0.525	0.932
CTJUN10	1644	2	0.3	29.77	7.55	7.1	50.3	0.068	33	10.3	0.826	0.456
				29.75	7.54	6.78	50.4	0.07	32.9	10.6	1.057	0.4
CTJUN24	1546	1.3	0.8	32.16	7.62	4.86	51.7	0.155	34.1		1.064	0
				32.2	7.61	4.67	52	0.153	34.3		2.079	0
CTJUL23	1546	1.3	0.8	32.16	7.62	4.86	51.7	0.155	34.1		1.106	0
				32.2	7.61	4.67	52	0.153	34.3		1.176	0
CTAUG6	1238	2.1	0.7	31.94	7.6	5.02	47.5	0.144	31	6.1	0.2263	0
				31.6	7.6	4.74	47.7	0.143	31.1	5.5	0.4745	0
CTSEP2	1221	0.9	0.8	31.55	7.46	4.05	43.8	0.13	28.2	5.4	1.665	0.537
				31.56	7.46	4.16	43.9	0.128	28.4	8.4	0.84	0.312

ST40	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1717	2.8	0.5	25.21	7.84	6.28	53.4	0.183	35.2	4.2	0.931	0.451
				25.19	7.82	6.23	53.4	0.181	35.3	10	0.812	0.151
CTAPR29	1350	2.6	0.7	24.74	7.56	7.04	56.2	0.247	37.4	6.2	-0.042	0.146
				24.44	7.57	6.64	56.2	0.242	37.3	2.1	-0.063	0.35
CTMAY13	1641	2.2	0.6	28.25	EQ MAL	5.45	55.9	EQ MAL	37.1	7	5.138	2.176
				28.37	EQ MAL	5.29	56	EQ MAL	37.2	10.4	5.068	2.276
CTMAY27	16.35	3.6	0.6	27.48	7.75	6.75	50	0.244	32.8	6	0.819	0.625
				27.31	7.73	6.19	50.6	0.239	33.2	8	0.6862	0.527
CTJUN10	1654	1.4	0.5	29.57	7.55	6.75	50.4	0.062	33.1	10.2	0.735	0.551
				29.55	7.54	6.41	50.4	0.066	33.1	10.6	0.651	1.212
CTJUN24	1536	3	0.7	31.94	7.66	4.96	52.6	0.156	34.7	2	1.134	0.649
				31.87	7.64	4.66	52.7	0.154	34.8	2	0.798	1.006
CTJUL23	1536	3	0.7	31.94	7.66	4.96	52.6	0.156	34.7	6.2	1.561	0
				31.87	7.64	4.66	52.7	0.154	34.8	10	0.959	0
CTAUG6	1226	5.5	0.7	31.99	7.65	5.68	47.5	0.148	30.9	0.05	0.6351	0.824
				31.41	7.62	4.71	47.9	0.145	31.1	1.8	0.4745	0.363
CTSEP2	1212	4.7	0.8	31.56	7.5	5.18	44.5	0.122	28.7	5.2	0.5925	0.151
				31.41	7.51	4.6	44.6	0.121	28.8	4.4	0.9	0.136

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0.0137	0.0081	0.0042	0.4238				
CTAPR29	0.0233	0.013	0.004	0.4222	0.5809	15.0005	18.9193	-0.9835
CTMAY13	0.0112	0.0352	0.0032	0.7351	0.2854	5.0207	5.5817	1.7324
CTMAY27	0.0108	0.2926	0.0109	0.8122	0.2348	2.2562	1.8137	-0.3783
CTJUN10	0.0337	1.4035	0.0113	1.9534	0.44	3.7374	4.3844	11.8317
CTJUN24	2.6415	0	0.2199	-0.1716	0.2448	1.537	2.3494	3.1665
CTJUL23	0	0.0068	0.0041	0.9669	0.4537	5.6043	7.5759	8.1756
CTAUG6	0.0117	0.003	0.0072	0.7785	0.1974	1.2809	2.0916	2.048
CTSEP2	0.7039	0.3297	0.1602	-1.2809	0.3777	6.564	8.4794	5.3982

ST50	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1659	1.5	0.8	25.21	7.86	6.24	53.6	0.17	35.5	4	0.91	0.654
				25.19	7.86	6.63	53.8	0.168	35.6	5	0.686	0.681
CTAPR29	1339	1.7	1	24.28	7.62	7.21	56.1	0.218	37.4	2.2	0.084	0.212
				24.25	7.59	6.85	56.2	0.21	37.4	2.1	-0.035	0.246
CTMAY13	1625	1.3	0.5	28.33	7.55	6.46	56.6	0.136	37.7	4	4.9368	2.252
				28.4	7.55	6.15	56.7	0.141	37.8	9	5.0094	2.448
CTMAY27	1619	1.7	0.7	27.66	7.8	6.91	50.4	0.229	33.1	7	0.8833	0.276
				27.66	7.78	6.79	50.5	0.224	33.1	4	1.2702	0.334
CTJUN10	1706	1.5	0.3	29.9	7.57	6.74	50.7	0.076	33.2	24	0.728	0.57
				29.2	7.56	6.33	50	0.077	33.2	33	0.812	0.569
CTJUN24	1525	1.4	0.7	31.98	7.77	6.35	53.3	0.149	35.2	1.9	1.323	0.998
				32.01	7.77	6.16	53.4	0.147	35.2	5	1.225	0.75
CTJUL23	1525	1.4	0.7	31.98	7.77	6.35	53.3	0.149	35.2	6.6	1.561	0
				32.01	7.77	6.16	53.4	0.147	35.2	10	2.45	0
CTAUG6	944	1.8	0.5	31.2	7.51	5.45	47.8	0.051	30.9	10.2	0.4161	0.394
				31.24	7.54	5.26	47.8	0.052	30.9	20.1	0.4015	0.425
CTSEP2	841	1.7	0.8	30.14	7.6	5.68	46.5	0.098	30.2	6.2	1.1461	0.224
				30.19	7.59	5.43	46.5	0.098	30.2	5.6	1.2629	0.177

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0.0075	0.0061	0.0021	0.3653				
CTAPR29	0.0259	0.0087	0.0029	0.4549	0.1565	18.2446	4.0279	-16.0837
CTMAY13	0.0125	0.033	0.0017	0.5486	0.2708	2.9121	3.7623	7.5726
CTMAY27	0.0119	0.2304	0.0078	0.5649	1.137	33.914	40.5118	44.5579
CTJUN10	0.0312	1.4469	0.0184	3.4664	0.2093	0.9455	1.1023	-3.1017
CTJUN24	2.9811	0.01	0.1702	-0.5447	0.2251	3.399	4.5387	1.9129
CTJUL23	0	0.0113	0.0041	0.4463	0.4237	5.3391	7.5631	6.4248
CTAUG6	0.0131	0.0384	0.005	0.5305	1.755	46.7356	60.2715	66.1235
CTSEP2	0.3121	0.5653	0.0442	-0.3586	0.3167	5.9128	7.9088	4.1986

ST60	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1623	1.2	0.8	25.76	7.79	6.59	49.5	0.193	32.4	3.4	1.0877	0.306
				25.51	7.77	6.34	49.9	0.19	32.7	4	0.6059	0.371
CTAPR29	1303	0.5	0.5	24.53	7.43	6.46	55.2	0.252	26.5	2	-0.0988	0.181
				24.53	7.43	5.42	55.1	0.24	26.6	2	-0.418	-0.065
CTMAY13	1445	1.5	0.8	28.74	7.47	5.41	56.3	0.222	37.4	1	4.781	2.321
				28.76	7.45	5.18	56.4	0.22	37.4	4	4.718	2.379
CTMAY27	1555	2.1	0.7	27.71	7.75	6.92	48.9	0.241	31.9	4	0.5402	0.233
				27.57	7.72	6.58	49	0.237	32	6	0.5402	0.245
CTJUN10	1609	1.3	0.5	29.96	7.56	7.2	47.7	0.057	31.1	8	0.9052	0.371
				29.96	7.55	6.96	47.7	0.059	31.1	16	1.1315	0.234
CTJUN24	1437	1.2	1	32.33	7.62	5.24	49.8	0.145	32.6	8.6	0.861	0.769
				32.22	7.61	4.94	49.8	0.143	32.6	6.6	0.994	0.539
CTJUL23	1437	1.2	1	32.33	7.62	5.24	49.8	0.145	32.6	1.6	0.987	0.147
				32.22	7.61	4.94	49.8	0.143	32.6	7.1	0.651	0.501
CTAUG6	1157	1.9	0.9	32.26	7.54	4.74	43.7	0.144	28.1	6.6	0.12	0.103
				31.87	7.53	4.38	44.4	0.144	28.8	7.1	0.2625	0.157
CTSEP2	1115	1.2	1.1	31.55	7.47	5.38	40.2	0.165	25.7	9.2	0.5472	0.078
				31.59	7.47	4.79	40.3	0.161	25.7	10.2	0.4636	0.297

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0.0112	0.0427	0.009	0.9842				
CTAPR29	0.0466	0.039	0.0086	1.0033	0.5002	13.4545	17.779	-9.1591
CTMAY13	0.015	0.0925	0.0017	0.7487	0.2461	1.2661	1.5128	-5.3258
CTMAY27	0.013	0.2465	0.0102	1.1333	0.5229	13.6622	16.1129	14.1952
CTJUN10	0.0137	1.2451	0.0216	1.0372	0.328	3.1824	3.264	-1.3768
CTJUN24	0.3585	0.004	0.2199	-0.5653	0.298	5.0016	6.6192	2.7342
CTJUL23	0	0.0068	0.0078	2.0578	0.3227	4.1625	5.419	4.7876
CTAUG6	0.0206	0.0423	0.0208	1.5546	0.3099	5.3318	6.8929	4.7551
CTSEP2	0.4858	1.358	0.2321	-1.4701	0.5469	15.2885	19.6229	5.4954

ST70	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1604	2.8	0.4	25.47	7.79	7.3	51.3	0.147	33.7	5.2	0.949	0.639
				25.35	7.78	6.7	51.4	0.148	33.8	3	0.438	0.225
CTAPR29	1443	3.3	0.4	24.84	7.46	7.13	55.6	0.242	26.8	3.1	-0.1216	0.189
				24.54	7.46	6.4	55.7	0.232	37.1	2.1	-0.165	0.135
CTMAY13	1545	1.8	0.5	27.82	7.58	6	54.5	0.237	36.3	6	5.061	0.571
				28.44	7.48	5.42	56	0.233	37.3	7	5.117	0.434
CTMAY27	1545	3.2	0.6	27.16	7.72	6.07	49.2	0.233	32.1	4	0.3285	0.272
				27.12	7.7	5.96	49.3	0.23	32.3	6	0.5256	0.187
CTJUN10	1548	2	0.6	29.4	7.51	6.16	48.2	0.067	31.4	4	0.7884	0.19
				29.39	7.5	5.83	48.2	0.07	31.4	4	0.9198	0.166
CTJUN24	1453	3.1	1	32.03	7.62	4.93	50.5	0.143	33.1	8.2	1.239	0.521
				32.04	7.61	4.7	50.8	0.141	33.4	7.2	0.945	0.616
CTJUL23	1453	3.1	1	32.03	7.62	4.93	50.5	0.143	33.1	6.2	1.008	0.054
				32.04	7.61	4.7	50.8	0.141	33.4	9.2	1.26	0.337
CTAUG6	1211	3.5	1	31.98	7.6	5.45	45.2	0.143	29.3	7.6	1.0575	0.394
				31.64	7.57	4.73	46.1	0.143	29.8	0.3	0.7154	1.188
CTSEP2	1150	2.8	1.2	31.3	7.47	4.92	41.2	0.078	26.4	6.2	0.5244	0.393
				31.27	7.46	4.44	41.3	0.081	26.4	3.8	0.3268	0.09

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0.0012	0.0102	0.0032	0.4889				
CTAPR29	0.0181	0.0087	0.008	1.3702	0.4337	8.3461	11.4915	-2.8315
CTMAY13	0.0187	0.0308	0.0081	0.6687	1.0396	31.2687	39.4147	-5.5376
CTMAY27	0.0173	0.2373	0.0068	0.3483	0.145	1.6569	1.5804	0.9834
CTJUN10	0.025	3.0108	0.0281	2.2183	0.1984	1.1613	1.1682	0.9078
CTJUN24	0.4906	0.008	0.1773	0.5216	0.1781	1.0389	1.592	3.0314
CTJUL23	0	0.0045	0.003	0.6667	0.1938	-0.1538	0.3331	4.2202
CTAUG6	0.0145	0.0157	0.0053	0.708	0.6589	15.6186	19.4768	11.6015
CTSEP2	0.4681	0.9623	0.1123	1.5212	0.5281	14.4972	18.5813	4.4255

ST80	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1544	1.9	0.6	25.38	7.81	7.58	52.2	0.156	34.3	6.4	0.584	0.492
				24.84	7.8	6.76	52.8	0.157	34.4	3.4	0.8103	0.375
CTAPR29	1228	2.7	0.5	24.85	7.46	7.71	55.8	0.218	37.1	3	0.203	0.233
				24.29	7.47	6.76	56.3	0.209	37.4	2.1	-0.028	0.287
CTMAY13	1600	0.9	0.5	28.79	7.58	6.54	56.6	0.224	37.6	9.4	5.1876	0.311
				28.83	7.6	6.3	56.6	0.216	37.5	6	5.214	0.401
CTMAY27	1530	2.5	0.8	27.58	7.79	7.03	49.8	0.236	32.6	8.4	0.84	-0.118
				27.37	7.79	6.54	50.3	0.215	32.9	8	0.623	0.181
CTJUN10	1530	2	1.2	29.19	7.44	6.97	49	0.052	32.1	10	1.095	0.214
				29.16	7.54	6.68	49	0.056	32.1	8	1.1534	0.2
CTJUN24	1504	1.9	0.7	32	7.7	5.78	52	0.145	34.3	6.6	1.022	0.6
				31.84	7.69	5.58	52.3	0.143	34.3	3.2	1.547	0.606
CTJUL23	1504	1.9	0.7	32	7.7	5.78	52	0.145	34.3	7.8	1.309	0.417
				31.84	7.69	5.58	52.3	0.143	34.3	9.2	1.547	0.589
CTAUG6	1007	3.2	0.5	30.97	7.66	5.95	46.1	0.099	29.8	6	0.9855	0.371
				30.95	7.66	5.8	46.1	0.1	29.9	20.2	1.1534	0.4
CTSEP2	910	3.1	1.3	30.24	7.58	5.58	44.2	0.075	28.6	6.2	0.5476	0.094
				30.08	7.55	4.69	44.4	0.081	28.7	15	1.0804	0.278

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0	0.0203	0.0016	0.5434				
CTAPR29	0.0181	0	0.008	1.677	0.1383	16.452	16.1568	2.7504
CTMAY13	0.0087	0.0264	0.0069	0.8862	0.417	9.233	11.0079	5.6511
CTMAY27	0.0076	0.2097	0.0058	0.9076	0.0894	1.129	1.1372	0.2756
CTJUN10	0.0375	1.0759	0.0254	0.7721	0.2056	2.5565	2.8354	-4.6222
CTJUN24	0.1509	0	0.0709	0.4155	0.2799	3.7164	4.9991	3.4799
CTJUL23	0	0.0091	0.0037	1.0393	0.287	3.5728	4.9281	5.6738
CTAUG6	0.0074	0.0168	0.004	0.5794	1.1259	26.4238	34.6038	8.7214
CTSEP2	0.1897	0.8291	-0.0764	0.9765	0.4738	11.4218	14.6624	24.435

ST90	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1459	1.4	0.7	26.01	7.73	6.7	42.7	0.205	27.5	4.3	0.6525	0.257
				25.44	7.69	5.93	46	0.198	29.9	3.3	0.465	0.528
CTAPR29	1044	0.5	0.5	24.5	7.41	6.44	38	0.245	24.1	2	0.078	0.142
				24.48	7.35	5.84	38.6	0.236	24.4	5.1	-0.0624	0.165
CTMAY13	1355	1.7	0.7	29.04	7.38	5.01	54.1	0.197	35.8	8.8	4.69	0.229
				28.96	7.36	4.82	54.3	0.195	35.9	3	4.543	0.629
CTMAY27	1445	2.5	0.8	28.1	7.64	6.24	42.6	0.226	27.4	6.6	0.5624	0.123
				27.37	7.63	5.69	46.5	0.222	30	3	0.3212	0.339
CTJUN10	1422	2.5	0.6	29.52	7.35	6.75	39.7	0.045	25.3	10	0.702	0.232
				28.95	7.44	5.64	45.4	0.051	29.3	9.4	0.855	0.086
CTJUN24	1416	1.4	0.9	32.69	7.55	5.79	34.5	0.134	21.6	4.6	1.62	0.51
				32.04	7.52	4.47	41.6	0.134	26.6	10	0.988	0.732
CTJUL23	1416	1.4	0.9	32.69	7.55	5.79	34.5	0.134	21.6	2.5	1.1907	0.038
				32.04	7.52	4.47	41.6	0.134	26.6	1.1	0.3724	0.194
CTAUG6	1132	2.6	0.9	31.67	7.42	5.24	28	0.139	17.2	5.6	0.323	0.215
				31.75	7.49	4.21	40.6	0.138	25.9	9.8	0.2736	0.375
CTSEP2	1036	2.5	1.4	30.46	7.41	5.15	28.3	0.163	17.3	4.2	0.5208	-0.006
				31.22	7.45	3.85	37.8	0.161	23.9	3.8	0.4758	0.066

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0.0062	0.0325	0.009	0.7639				
CTAPR29	0.0362	0.0738	0.0143	1.4968	1.0173	31.0882	37.6552	-11.234
CTMAY13	0.02	0.022	0.0127	1.4031	0.213	3.6293	4.4733	3.2983
CTMAY27	0.0119	0.076	0.0088	1.543	0.1059	1.2513	1.1264	0.6809
CTJUN10	0.0387	1.1041	0.0259	0.5534	0.2323	4.4809	5.0332	5.2804
CTJUN24	1.6792	0	0.227	0.0579	0.2782	4.7136	5.6378	1.6265
CTJUL23	0	0.0159	0.0119	2.7404	0.9502	24.9447	30.9436	12.0121
CTAUG6	0.0141	0.0346	0.0216	1.8797	2.0358	62.5773	77.332	3.7339
CTSEP2	0.3511	0.5518	0.122	-0.6752	0.7567	22.5882	28.6511	35.8419

ST100	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1513	1.6	0.5	25.23	7.76	6.55	49.3	0.182	32.2	3.3	0	0.617
				25.24	7.75	6.29	49.5	0.18	32.3	3.2	0	1.018
CTAPR29	1155	1.6	1	24.49	7.29	6.3	52.1	0.104	34.3	2.2	0.049	0.096
				24.48	7.34	4.73	52.1	0.104	34.3	2.2	-0.168	0.115
CTMAY13	1409	3	0.8	28.84	7.46	5.52	56	0.217	36.5	2	0	0.279
				28.82	7.45	5.2	56	0.21	36.5	2	0	0.292
CTMAY27	1456	3.4	0.9	27.3	7.69	6.19	48	0.232	31.3	8	0.5256	0.122
				27.25	7.68	5.85	48.2	0.229	31.4	1	0.5621	0.118
CTJUN10	1441	2	0.5	29.25	7.34	6.51	46.1	0.041	29.9	10	0.9344	0.14
				29.24	7.47	5.88	46.1	0.047	29.9	10.6	0.9636	0.192
CTJUN24	1427	3.3	0.9	32.18	7.59	4.73	47.2	0.135	30.7		11.826	0.421
				32.1	7.57	4.55	47.7	0.133	31.1		0.4161	0.65
CTJUL23	1427	3.3	0.9	32.18	7.59	4.73	47.2	0.135	30.7	5.8	1.1753	0.815
				32.1	7.57	4.55	47.7	0.133	31.1	5.4	0.6789	0.047
CTAUG6	1144	2.4	1	31.87	7.57	5.16	43.1	0.138	27.7	7.6	0.24	0.482
				31.77	7.56	4.74	43.4	0.137	27.8	8.2	0.75	0.448
CTSEP2	1046	3.1	1.3	31.08	7.44	4.61	36.4	0.149	23.1	2.8	0.8058	0.053
				31.18	7.45	4.25	37.6	0.147	23.9	3	0.2808	0.038

ST110	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1524	2.5	0.5	25.02	7.79	6.5	41.7	0.183	34	7	0.7373	0.309
				25.85	7.79	6.45	51.8	0.181	34.1	3.4	0.4964	0.45
CTAPR29	1203	1.6	0.7	24.37	7.39	7.03	55.8	0.109	37.1	8	0.399	0.278
				24.34	7.45	6.42	55.9	0.108	37.1	10	-0.098	0.511
CTMAY13	14.2	2.8	0.8	29.02	7.57	6.33	56.5	0.201	37.6	9.6	5.0292	0.147
				28.85	7.6	6.22	56.7	0.197	37.7	8.2	5.1612	0.28
CTMAY27	1505	3	1.2	27.55	7.78	6.8	49.9	0.226	32.7	5.6	0.693	0.276
				27.17	7.78	6.56	50.1	0.223	32.6	6.4	0.567	0.215
CTJUN10	1500	2.3	1	29.53	7.55	6.84	48.4	0.036	31.6	1	1.606	0.107
				29	7.58	6.68	49.1	0.04	32.1	1	1.2191	0.114
CTJUN24	1313	2.5	1	32.02	7.45	5.44	51.3	0.121	33.7	6	1.239	0.624
				31.64	7.58	5.73	51.7	0.117	33.9	6.6	1.463	0.483
CTJUL23	1313	2.5	1	32.02	7.45	5.44	51.3	0.121	33.7	3.1	1.225	0.027
				31.64	7.58	5.73	51.7	0.117	33.9	10	1.162	1.295
CTAUG6	1030	2.8	0.9	31.27	7.59	5.56	45.6	0.122	29.5	5.6	0.5767	0.381
				31.21	7.62	5.67	45.9	0.12	29.7	10.8	0.8541	1.549
CTSEP2	931	2.6	1.7	30.08	7.56	4.93	42.2	0.115	27.1	2.5	0.6308	0.187
				30.08	7.56	4.58	42.7	0.114	27.4	3.8	0.57	0.07

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0	0.0061	0.0027	0.5018				
CTAPR29	0.0129	0.0108	0.0074	1.8687	1.4076	40.9772	49.6264	24.9267
CTMAY13	0.0112	0.033	0.0072	0.4835	0.2338	5.1739	6.5263	5.8024
CTMAY27	0.0097	0.0737	0.0014	0.3131	0.072	0.9664	0.9268	3.0152
CTJUN10	0.0362	1.0716	0.0113	0.772	0.6502	19.0958	23.791	5.3409
CTJUN24	0.0377	0.004	0.1631	-1.031	0.1256	0.8201	1.2903	1.0915
CTJUL23	0	0.0023	0.0041	0.38	0.0942	-0.2473	0.5106	2.3992
CTAUG6	0.0085	0.0266	0.0051	0.5338	0.6063	13.588	18.0094	1.0807
CTSEP2	0.1879	0.1938	-0.0734	0.5881	0.3546	8.1027	10.4854	4.6471

ST120	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1339	1.7	0.8	25.8	7.21	7.07	52	0.093	34.2	3.2	0.8541	0.363
				25.12	7.43	6.89	52	0.087	34.3	3.1	0.6789	0.348
CTAPR29	904	1.1	0.5	23.49	6.9	6.42	55.2	0.154	36.7	10.1	-0.133	0.202
				23.8	7.22	6.32	55.4	0.139	36.7	7.3	-0.028	0.229
CTMAY13	1300	2.7	1	28.78	6.92	6.44	56.5	0.191	37.5	6.2	5.1216	0.167
				28.69	7.31	6.26	56.6	0.184	37.6	10.3	5.115	1.789
CTMAY27	1330	2.1	1	27.25	7.64	6.69	49.8	0.19	32.6	8.2	1.197	0.085
				27.21	7.67	6.66	50	0.186	32.7	6.8	0.77	0.499
CTJUN10	1306	2.1	1.2	28.89	7.47	6.58	48.9	0.131	31.9	9.6	1.3724	0.488
				28.67	7.51	6.44	49	0.129	32	7.4	1.1607	0.178
CTJUN24	1327	3.2	1.3	31.78	7.68	6	51.6	0.122	34	4.6	1.309	0.586
				31.18	7.66	5.49	51.6	0.122	33	7.2	1.372	0.364
CTJUL23	1327	3.2	1.3	31.78	7.68	6	51.6	0.122	34	7.6	1.281	0.086
				31.18	7.66	5.49	51.6	0.122	33	8.4	1.302	0.831
CTAUG6	1041	2.8	1	31.2	7.62	5.51	46	0.125	29.8	8.6	0.8906	0.454
				31.24	7.6	5.23	46	0.125	29.8	7.4	0.5621	0.143
CTSEP2	941	2.6	1.4	30.06	7.57	5.65	42.8	0.117	27.5	2.5	0.84	0.117
				30.14	7.56	5.04	43.2	0.117	27.8	2.8	0.8775	0.305

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0	0.0041	0.0016	0.2681				
CTAPR29	0.0155	0.0022	0.0023	1.8627	0.1871	5.4622	7.7123	-6.7923
CTMAY13	0.0075	0.0374	0.0075	1.0051	0.1106	5.6703	5.7869	-4.9097
CTMAY27	0.0043	0.053	0.002	0.4365	0.1174	1.6746	1.8981	-0.4485
CTJUN10	0.0162	1.026	0.0162	0.0662	0.2706	6.6737	7.8725	7.1641
CTJUN24	0.0377	0.0399	0.0993	0.2517	0.0927	0.5848	0.8651	1.6913
CTJUL23	0	0.0023	0.0022	1.2749	0.2188	1.9153	2.8714	2.972
CTAUG6	0.0069	0.0526	0.0036	0.4781	0.7093	15.4668	19.7055	10.8125
CTSEP2	0.1809	1.2692	-0.0749	0.7524	0.3461	8.032	10.2336	2.7234

ST130	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1428	1.5	0.9	25.02	7.74	6.27	48.6	0.207	31.8	2.4	1.4819	0.289
				25.25	7.71	5.97	48.7	0.196	31.8	2.5	0.73	0.322
CTAPR29	1013	0.7	0.7	24.17	7.45	5.96	52.7	0.262	34.8	7	-1.008	0.118
				24.18	7.44	5.56	52.7	0.253		4.4	0.035	0.142
CTMAY13	1340	1.6	0.8	28.78	7.43	5.15	56	0.177	37.2	9.8	4.557	0.122
				28.79	7.42	4.91	56	0.175	37.2	4	4.585	0.297
CTMAY27	1420	1.4	0.9	27.34	7.69	6.06	49.3	0.229	32.2	9.2	0.6424	0.556
				27.35	7.68	5.94	49.3	0.225	32.2	9.2	0.4964	0.298
CTJUN10	1403	1.6	0.8	29.26	7.53	5.8	47.8	0.042	31.2	6.4	0.5548	0.108
				29.28	7.52	5.79	47.7	0.046	31.1	7.2	0.6205	0.365
CTJUN24	1402	1.7	1.3	32.17	7.63	5.16	49.3	0.133	32.2	2	1.2702	0.315
				32.17	7.63	5.24	49.3	0.132	32.2	3.4	1.1753	0.415
CTJUL23	1402	1.7	1.3	32.17	7.63	5.16	49.3	0.133	32.2	5.2	1.4746	0.479
				32.17	7.63	5.24	49.3	0.132	32.2	4.8	1.0366	0.548
CTAUG6	1120	1.5	0.9	31.82	7.58	4.99	43.2	0.136	27.7	6.4	0.6278	0.5
				31.84	7.57	4.77	43.2	0.134	27.8	9.2	0.5475	0.443
CTSEP2	1021	1.6	1.2	31.05	7.48	4.4	39.4	0.156	25.1	3.2	0.462	0.205
				31.03	7.48	4.31	39.6	0.152	25.2	3.6	0.5852	-0.057

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0.0062	0.0325	0.009	0.5672				
CTAPR29	0.031	0.0108	0.0057	1.2057	0.2436	6.7672	9.3645	8.9969
CTMAY13	0.0062	0.0352	0.0119	1.3674	0.2892	7.6683	9.1766	7.1187
CTMAY27	0.0065	0.0369	0.0044	1.2316	0.2511	6.2005	7.1501	5.4738
CTJUN10	0.01	1.2191	0.0119	0.1538	0.2009	4.4177	5.1496	3.3816
CTJUN24	0.1321	0.0219	0.2057	0.5191	0.1153	0.7114	0.9833	0.7295
CTJUL23	0	0.0045	0.016	0.5817	0.1927	1.299	2.0713	1.9021
CTAUG6	0.015	0.0333	0.0209	0.5874	0.7253	16.6322	21.8246	7.4569
CTSEP2	0.4468	1.1252	0.1557	-0.8556	0.3743	10.5196	13.0958	6.5113

ST140	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1411	4	0.5	25.01	7.68	6.67	49.9	0.169	32.7	3.3	0	0.504
				25.1	7.68	6.28	49.9	0.165	32.7	3	0	0.206
CTAPR29	938	2.4	0.5	23.96	7.4	6.29	53.4	0.256	35.3	4.4	0.049	0.121
				23.96	7.39	5.88	53.5	0.246	35.4	4.1	-0.322	0.277
CTMAY13	1330	4.8	1	28.66	7.45	5.77	56.3	0.169	37.4	9.6	0	0.156
				28.63	7.46	5.51	56.1	0.166	37.5	8.8	0	0.184
CTMAY27	1412	4.5	1.2	27.1	7.71	6.25	49.3	0.22	32.3	6.2	0.9198	0.311
				27.1	7.71	6.22	49.3	0.215	32.3	6.2	0.7008	0.202
CTJUN10	1347	3	0.9	28.92	7.51	6.14	48.1	0.05	31.3	6.4	0.8395	0.121
				28.87	7.51	5.84	48.1	0.054	31.4	6.4	0.9782	0.115
CTJUN24	1354	4.6	1.1	31.98	7.63	5.1	49.9	0.137	32.7	3.8	0.875	0
				31.71	7.6	4.56	50.2	0.136	32.8	4.2	0.917	0
CTJUL23	1354	4.6	1.1	31.98	7.63	5.1	49.9	0.137	32.7	4.4	1.099	0.659
				31.71	7.6	4.56	50.2	0.136	32.8	4.4	1.043	0.832
CTAUG6	1112	4.3	1.5	31.45	7.6	5.21	44.1	0.138	28.5	8.2	-0.2263	0.708
				31.5	7.59	5.04	44.3	0.136	28.6	10	0.9563	0.798
CTSEP2	1010	4.2	1.4	30.93	7.51	5.23	40.4	0.16	25.9	2.9	0.3648	-0.242
				31	7.52	4.66	41	0.158	26.2	5.2	0.646	0.075

ST150	time	depth	secchi	s/b temp	s/b ph	s/b do	s/b cond	s/b orp	s/b sal	s/b turb	s/b bod	s/b ss
		m	m	C	pH	mg/l	mmhos/cm	volts	ppt	NTU	mg/l	mg/l
CTAPR15	1352	2.2	0.8	25.34	7.63	7.05	50.1	0.135	32.8	4.3	0.657	0.224
				24.65	7.66	6.7	51.1	0.13	33.7	4.2	0.9125	0.345
CTAPR29	1919	2.4	0.7	23.9	7.35	6.1	54.1	0.159	35.9	7.4	-0.112	0.146
				23.93	7.36	5.81	54.3	0.153	35.9	5.3	-0.217	0.125
CTMAY13	1315	3.4	0.8	29.15	7.46	6.27	56.3	0.171	37.4	6.2	5.222	0.142
				28.69	7.47	5.97	56.7	0.167	37.7	5.4	4.9896	0.185
CTMAY27	1355	3	1	27.44	7.69	6.79	48.6	0.211	31.8	6	0.803	0.257
				27.25	7.72	6.58	49.6	0.207	32.5	8.6	0.63	0.289
CTJUN10	1326	1.9	1	29.4	7.55	6.86	47.9	0.082	31.2	8.2	0.4964	0.232
				28.92	7.56	6.66	48.4	0.083	31.5	7.2	1.7447	0.081
CTJUN24	1340	3.4	1.1	31.88	7.67	5.82	51.4	0.129	33.8	4.6	1.253	0.401
				31.53	7.66	5.55	51.9	0.129	34.1	1.2	1.54	0.469
CTJUL23	1340	3.4	1.1	31.88	7.67	5.82	51.4	0.129	33.8	1.5	1.246	0.105
				31.53	7.66	5.55	51.9	0.129	34.1	4	1.309	0.114
CTAUG6	1054	2.8	0.9	30.88	7.47	3.93	42.9	0.131	27.5	8.2	0.2482	0.407
				31.17	7.62	5.55	45.2	0.125	29.2	9.4	0.9855	0.798
CTSEP2	955	2.1	1.8	30.46	7.55	5.23	41.7	0.138	26.8	2.6	1.3148	0.171
				30.43	7.54	4.73	42.2	0.137	27	2.8	0.555	0.112

date	po4	nh4	no2	no3	chl a	chl b	chl c	phaeo
	ug-at/l	ug-at/l	ug-at/l	ug-at/l	mg/m3	mg/m3	mg/m3	mg/m3
CTAPR15	0	0.0061	0.0027	0.7064				
CTAPR29	0.031	0.0174	0.012	2.395	0.5433	17.9816	24.6341	23.1381
CTMAY13	0.0037	0.0374	0.0055	0.5298	0.3801	10.0731	12.4443	5.5527
CTMAY27	0.0043	0.0207	0.002	0.6167	0.8816	27.763	34.3376	18.1668
CTJUN10	0.0087	1.0846	0.0162	0.1404	0.255	4.7672	5.4077	0.8397
CTJUN24	0.1132	0.004	7.4184	-69.2686	0.0776	0.62	0.8815	1.0753
CTJUL23	0	0.0068	0.0119	0.7781	0.308	2.7736	4.1025	3.8149
CTAUG6	0.0044	0.0026	0.0096	0.3244	0.5882	12.9101	16.6166	7.5218
CTSEP2	0.2801	0.175	-0.0569	0.5626	0.3574	8.9032	11.2089	2.5667